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# OPERATING
# AND
# SERVICE MANUAL

MP MASTER
MA23375

LYONS INSTRUMENTS

# OPERATING AND SERVICING MANUAL

## TYPE PG-71

## PULSE GENERATOR

Serial No. 71051

Designed and manufactured in England by:

LYONS INSTRUMENTS LIMITED

Telephone: Hoddesdon 67161 Telex 22724

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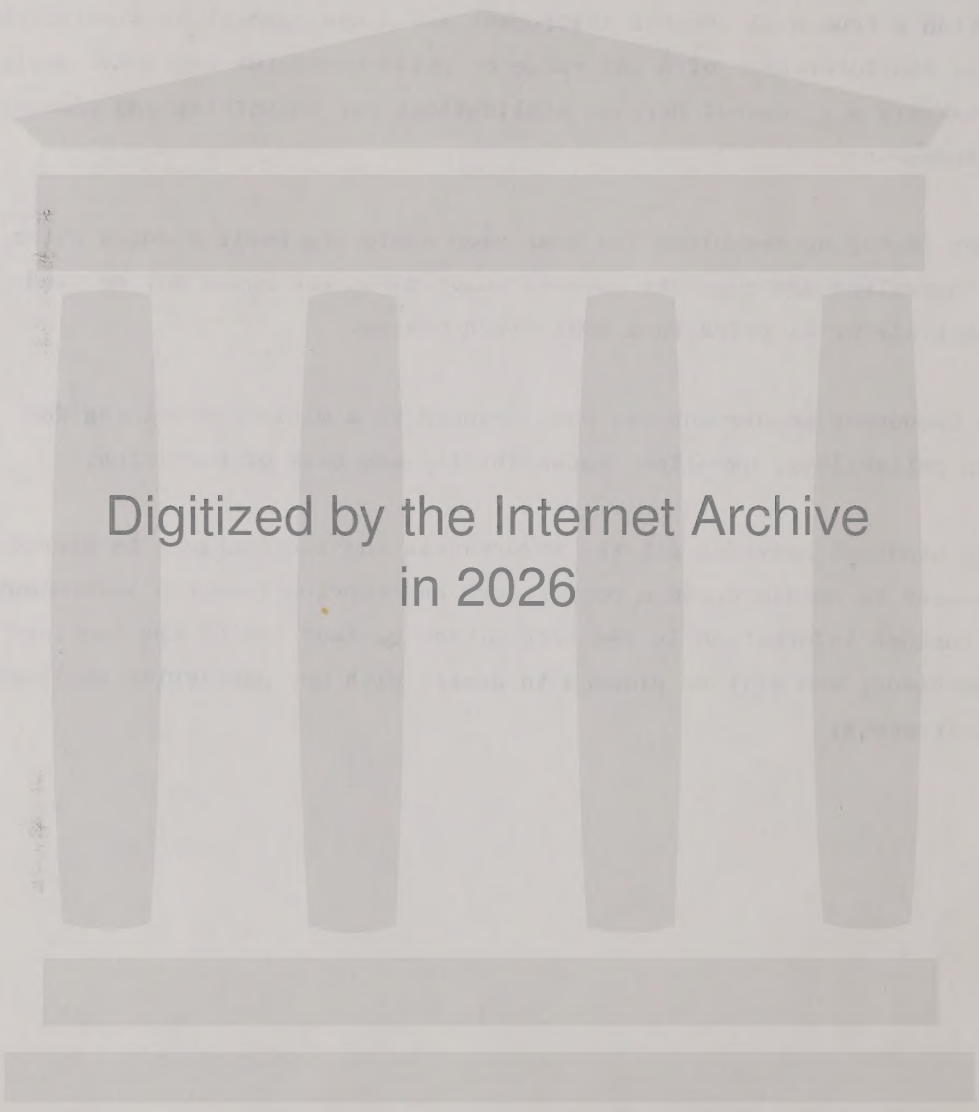
# INTRODUCTION

The Lyons Instruments Type PG-71 is an all solid state Pulse Generator using TTL integrated circuits and silicon transistors throughout to provide a true dual channel instrument and a new concept in flexibility. It is the forerunner of a new range of Pulse Generator equipment designed to satisfy all general purpose applications for industrial and educational environments.

A new packaging technique has been used employing basic modules which in themselves are complete powered instruments and hence may be used separately or as pairs in a dual width cabinet.

The component complement has been reduced to a minimum providing for high reliability, excellent accessibility and ease of servicing.

This handbook provides all the information and instructions to enable the user to obtain optimum performance and service from the instrument. If further information is required please contact the LI Engineering Department, who will be pleased to assist with any particular application requirements.



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## SECTION 2

### GENERAL DESCRIPTION

The PG-71 is a true double pulse generator having two independent Delay, Width and Output channels driven from a common clock pulse generator. The two output channels are positive polarity and can be combined by front panel toggle switches to provide double pulse operation on one or both channels thus allowing one channel to operate at twice the repetition rate of the other if required. Under certain operating conditions it is possible to overun the delay ranges and provide even greater division ratios for special applications.

Each of the pulse timing functions has a separate calibrated control which allows the pulse parameters to be set approximately without use of external equipment and provides facility for logging readings obtained when the instrument is used for qualitative measurements.

A sync output facility is provided on the front panel and external trigger and gate input sockets are fitted at the rear. A manual "one shot" push button is fitted adjacent to the sync output socket.

The instrument normally operates from mains supplies but modifications can be incorporated to allow operation from an external 24 volts D.C. supply, when a change over switch is fitted to the rear panel for supply selection.

Both output circuits are capable of driving 200 mA into 50 ohms and may be used in three basic modes;

| | | |
|---|---|---|
| (1). | 10 volts into High Impedance | (50 ohm source) |
| (2). | 5 volts into 50 ohms | (50 ohm source) |
| (3). | 10 volts into 50 ohms | (High Z source) |

Access to the source impedance links can be obtained by removing the module from its case and locating linking pins adjacent to each output amplifier. Either channel may be changed and used as required but the instrument will normally be despatched from the factory with the 50 ohm source resistor fitted.

## SECTION 3

## DESCRIPTION OF CONTROLS

### 3.1. Power On Switch and Indicator

The power on switch connects AC supply to the transformer primary winding or DC to the Bridge rectifier if the unit is modified for dual supply operation. The Power ON indicator is a 28 volt filament lamp connected to the +17 volt rail to provide an indication of the ON condition regardless of the supply connected.

### 3.2. Period Range Switch and Vernier

The Range switch selects a pair of capacitors, one for each arm of the period multivibrator, to determine the decade range selection and the 10:1 vernier provides a fine control calibrated as a direct multiplier of Range setting. The fully 'clockwise' position of the switch is identified EXT and when selected the internal multivibrator is inhibited allowing the Manual push-button or EXT. TRIG. socket to control the Delay circuits.

### 3.3. Manual Push Button or EXT Trigger Socket

These two facilities are only available when the Period Range Switch is placed in the EXT condition. A positive going pulse greater than 2V at the EXT trigger socket or depressing the push button will initiate the Delay circuits.

### 3.4. Gate Input

This socket enables a gated output to be achieved by inhibiting the period multivibrator for as long as the input socket is at a greater potential than +2 volts.

3.5. Delay Range Switches and Verniers

Both A and B delay functions are identical each providing 8 decade ranges by selecting a single capacitor in the timing monostable circuit. The verniers are fine controls calibrated 10:1 which may be used as a direct multiplier of the range setting. The function of these controls is to delay the output pulse on each channel by an amount equal to the respective dial setting relative to the sync output.

3.6. Width Range Switches and Vernier

The controls are electrically similar to the delay system but determine the width of the output pulses produced.

3.7. Amplitude Controls

Each control forms a simple attenuator across its respective output channel allowing a full range control of 0·5 to 10 volts EMF.

3.8. Channel Combining Switches

Each channel has its own combining switch which allows an effective cross-coupling before the output stages. With either switch to single channel working the output on that channel will be a pulse determined only by the related delay and width functions but in the combined positions both channel pulses will be available in serial form on the applicable output socket. The pulse pairs produced may each be controlled independently in width and delay, i.e. true double pulse. (See application notes - section 7).

3.9. Output Sockets

Three output sockets are provided as follows:-

| | | |
|---|---|---|
| (a). | Sync Output | 2 volt positive-going when terminated in 50 ohms. |
| (b). | A Output | 10 volts from 50 ohms (see Section 6.3.1.) |
| (c) | B Output | 10 volts from 50 ohms (see Section 6.3.2.) |

## SECTION 4

## OPERATING INSTRUCTIONS

### 4.1. Mains Supply

The instrument is despatched from the factory with internal source resistors connected in circuit and mains links set to 240V 50 Hz operation unless otherwise stated.

Disconnect unit from any external supply, remove module from case and observe mains input transformer fitted to rear panel. The transformer has two primary windings each providing taps at 110, 115 and 120V., which should be connected as follows:-

#### 4.1.1. 110-120V Operation

Connect both primaries in parallel at selected level to suit mains requirements.

#### 4.1.2. 220-240V Operation

Connect primaries in series i.e. link required high level terminal of Primary 1 to 0V of Primary 2 and connect line input (brown) to required high level terminal on Primary 2.

### 4.2. EXT DC Operation

This only applies when the EXT D.C. option is fitted:-

4.2.1. Connect EXT D.C. 24V supply to terminals provided observing correct polarity.

4.2.2. Place D.C. Mains switch (rear panel) to D.C. Check pulse generator operation as in para. 4.4.

4.3. Set source Z disconnect power supply and remove module from case. Locate link connection pins (3 off) adjacent to each output amplifier and connect links as follows:-

| SOURCE ZO | LOAD ZL | CHANNEL A LINK | CHANNEL B LINK | VOLTS ACROSS ZL |
|---|---|---|---|---|
| 50Ω | 500Ω Min. | P31 to P30 | P26 to P25 | 9 volts min. |
| 50Ω | 50Ω | P31 to P30 | P26 to P25 | 5 volts |
| HIGH | 50Ω | P29 to P30 | P24 to P25 | 10 volts |

4.4. Check Operation

4.4.1. Connect instrument to a suitable mains source (set supply links if necessary see paragraph 4.1.1. and 4.1.2.)

4.4.2. Connect BNC-BNC cables from the SYNC and Channel A output sockets to oscilloscope trigger and Y input respectively.

4.4.3. Set Pulse Generator controls as follows:-

Range Switches — 3rd switch position clockwise (10 µS period; 1µSec delays and widths).

Range Verniers — 3

Amplitude Controls — Maximum

Combine Switch — Up

4.4.4. Set oscilloscope to display a time base approximately 5µS/cm and observe Channel A output on CRT.

Check the pulse is as follows:-

Amplitude - 10 volts (some overshoot will be present with line unterminated).

Period 30µS approximately.

Delay 3µS approximately.

Width 3µS approximately.

4.4.5. Depress combined switch A and observe Channel B pulse is co-incident with A. Verify by increasing Delay B vernier to 6 and note width is now approx, 6µSecs. Return delay B vernier to 3.

4.4.6. Monitor output on Channel B socket, check as for 4.4.4. and 4.4.5. using Channel B combine switch and delay A vernier.

4.4.7. Return combine switches to the single channel condition and check all pulse generator ranges and verniers as required.

N.B. At minimum range setting timing functions will not operate when set significantly below specification limits.

4.4.8. Set oscilloscope time base to 100µS/cm and Delay range switch to 0·1µSec.

Set width A to 0·1ms and switch period switch to EXT. Check operation of manual push button.

4.4.9. Connect output from oscilloscope calibrator to EXT input socket on rear panel. Set calibrator amplitude to 5 volts - check pulse generator operation on both channels.

Re-check operation with calibrator set at 2 volts.

4.10. Connect calibrator O/P to gate socket, check delay is at approx. 0·1µSec and Period Switch to 10µSec range. Set width switches

to 1μSec and both verniers to 5. Check gated waveform is present on oscilloscope.

N.B. For checks 1.9. and 1.10. it is advisable to trigger the oscilloscope direct from the calibrator output and not the normal pulse generator sync output.

## SECTION 5

## CIRCUIT DESCRIPTION

### 5.1. General

The circuits used in the PG-71 have been derived as simply as possible, consistent with the performance requirements and practically all pulse timing functions are built around 74 series TTL integrated circuits. Discrete silicon semiconductors have been used only where necessary i.e. the output stages and for interfacing to external levels.

### 5.1.1. Block Diagram (Fig.5.1.)

The system period is determined either by the period generator, a multivibrator circuit described in 5.2., which can be gated by an inhibit signal to SKT1 (GATE input); by a manual one-shot pushbutton PB1; or by an external trigger signal to SKT2 (EXT input).

These signals feed via a pulse shaper to the sync. output amplifier and delay monostables (Channels A and B). Each delay output is then coupled via a shaper to the respective width monostable.

The channel A width monostable is connected permanently via Mixer A to drive the Channel A output amplifier, (similarly for Channel B). Mixer (channel combining) switches enable the output of Channel B width generator to be fed into the Channel A output stage and/or vice-versa. As will be seen later, these combining switches enable true double pulse outputs, with independent delay and width settings or one channel to operate at twice the PRF of the other.

The following paragraphs describe each section of the circuitry of the PG-71 in greater detail.

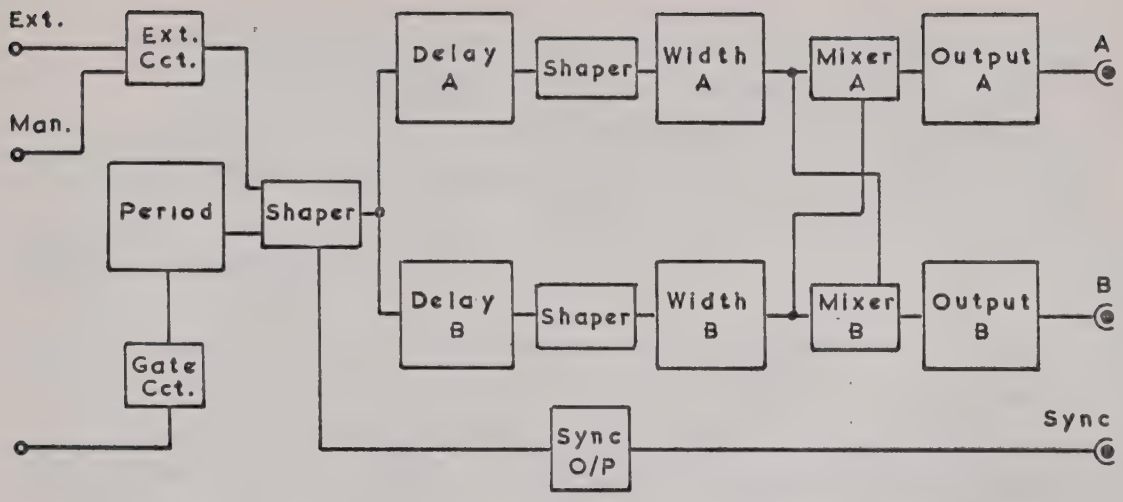



FIG 5.1. PG-71 BLOCK CIRCUIT DIAGRAM

## 5.2. Period Multivibrator (Fig. 5.2.)

The basic multivibrator consists of only two NOR Gates (A1 and A3) and transistors Q4 and Q5. The gates are cross-coupled via capacitor networks and form an astable multivibrator with transistors Q4 and Q5 in the feedback paths to ensure correct switching throughout the 10:1 range of the vernier control. Gate A2, Diodes D8 and D9 and Gate A4 are connected as an Exclusive OR function to monitor the collector states of A1 A3 and ensure that the basic multivibrator starts under all operating conditions. Fine control of the Period multivibrator is provided by RV2 and its range expansion preset RV1 RV3 which control the discharge rate of the multivibrator timing capacitors. Preset RV3 provides an effective "set minimum" control when calibrating the period vernier.

### 5.2.1. Gate Circuit

The gating circuit allows the clock to be inhibited by a signal of +2V or greater to the base of Q2 via SKT1 on the rear panel. The input pulse is coupled via Q2 and Q3 to inhibit the period multivibrator at pin 9 of Gate A3 and via D7 to disable the starting circuit A2, A4, D8, D9.

Diodes D4, D5, D6, protect the gate input circuit against excessive input levels by limiting the base of Q2 to approximately 2·5 volts. The maximum permissible input level is 20 volts D.C. equivalent.

5.2.2. External Input

External trigger signals may be applied to SKT1 in the form of positive going pulses of amplitude 2V or greater. Q1 acts as a buffer and passes the trigger pulses via C19 to the shaper network. Diodes D1, D2, D3 protect the external input circuits in a similar way to D4, D5, D6 in the gate circuit. Input signals must however, not exceed 20 volts D.C. equivalent.

5.2.3. Manual one-shot

Push-button PB1 provides a 'one-shot' facility and when pressed a trigger pulse is passed via C22 to shaper A thus initiating a single complete operating cycle of the two main pulse output channels and sync output.

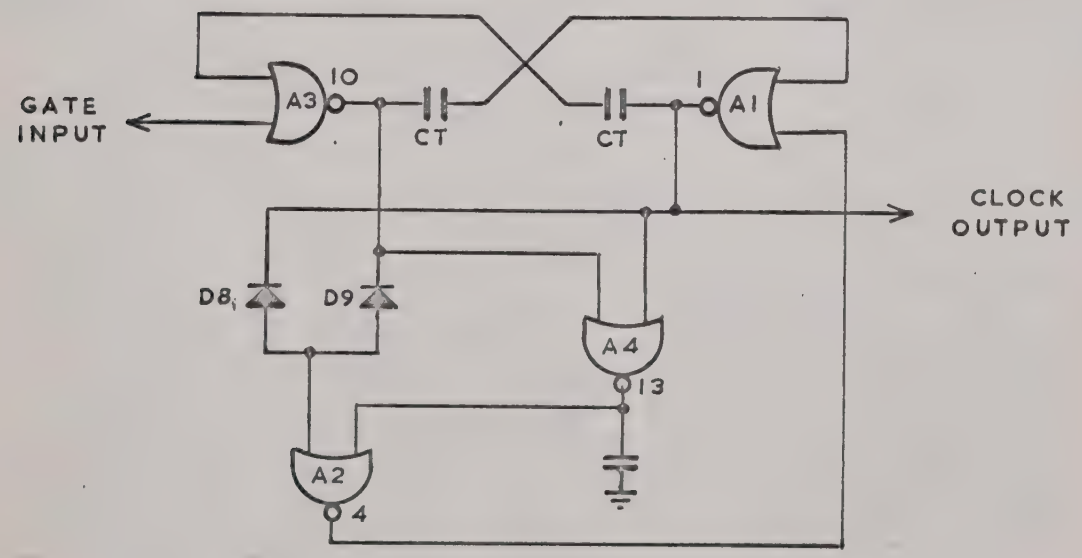
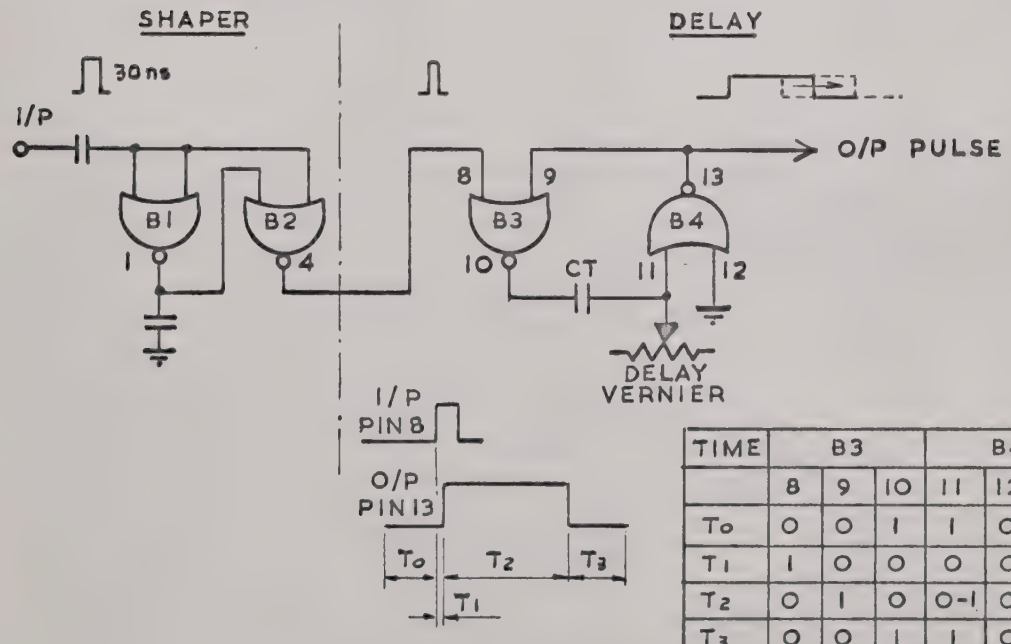



Fig 5.2. SIMPLIFIED MULTIVIBRATOR

5.3. Shaper/Delay A (Fig. 5.3.)

The output of the period multivibrator, Gate A1 is coupled via C20 to a shaping network comprising gates B1 and B2 as also are the output of the trigger buffer Q1 via C19 and the manual one-shot circuit via Q22. A short (30ns approx.) positive going pulse is produced at the collector of gate B2 each time the input to B1 falls to 0·8 volts or less, the length of the pulse being determined by the propagation delay of the gates and capacitor C21. The positive pulse is used as the datum pulse for the two Channel Delay generators and the sync output emitter follower Q6.

The delay (A) multivibrator is formed by gates B3 and B4 coupled as a monostable via one of the coarse range capacitors C25 to C32. RV5 and its associated limit trimmers RV4 and RV6 provide a fine delay adjustment by controlling the discharge rate of the selected range capacitor.




| TIME | B3 | | | B4 | | |
|---|---|---|---|---|---|---|
| | 8 | 9 | 10 | 11 | 12 | 13 |
| To | 0 | 0 | 1 | 1 | 0 | 0 |
| T1 | 1 | 0 | 0 | 0 | 0 | 1 |
| T2 | 0 | 1 | 0 | 0-1 | 0 | 1 |
| T3 | 0 | 0 | 1 | 1 | 0 | 0 |

FIG. 5.3. - SIMPLIFIED SHAPER/DELAY

5.4. Shaper/Width A/B

The output of Delay A (pin 13) is fed via C41 to a second shaper employing gates C3, C4 which provides a correctly shaped firing pulse for the Width monostable C1 C2 coincident with trailing edge of the Delay output pulse. The width monostable is formed by gates C1, C2 and timing capacitors C43 to C50. Fine Width control is provided by RV8 with presets RV7 and RV9 as its calibration trimmers.

The operation of the Shaper/Width circuitry is similar to that given in Fig. 5.3.

Gates E3, E4 similarly form a shaper feeding channel B width generator E1, E2.

The outputs of the two width generators are connected via the mixing circuit (para.5.5.) to the two output stages (para.5.6.).

5.5. Mixer (Fig.5.4.)

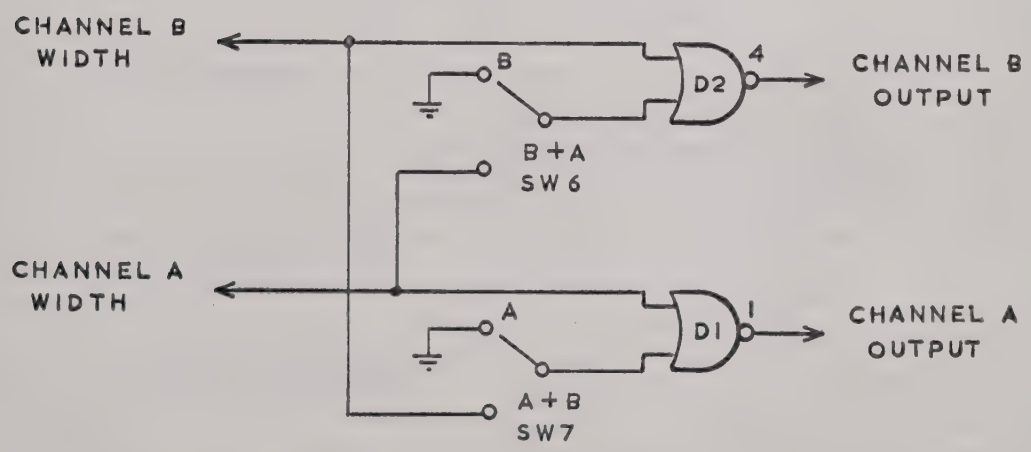



FIG. 5.4. - SIMPLIFIED MIXER.

Gates D1 D2 are used to form a channel mixing circuit. One input of gate D1 is permanently connected in the A signal path and the other is connected either to ground (A) or B width generator output (A+B) by front pannel switch (SW7).

Similarly SW6 is used to connect the A width generator output to mixer D2 in the B+A condition. These switches may be used to provide true double pulse operation on either channel independently or simultaneously as required.

5.6. Output Stages

Two identical output amplifiers are used each comprising a simple current switch Q10 (or Q11) driving parallel emitter followers Q7 to Q9 (Q12 to Q14) to provide the necessary current drive to the output load (200mA). For maximum flexibility, the source impedance R36 (R37) may be disconnected by removing the internal link L1A (L1b) as required and reconnecting the short across L2a (L2b) (See section 6) Diodes D10, D11 provide reverse voltage protection. Care should be taken to ensure that any reverse current does not exceed 40mA.

5.7. Power Supplies

MR1-MR-4 form the bridge rectifier providing approximately 24 volts to the stabiliser circuits. Q15, D12 regulate the high level supply at +17V and D13 the 5.4. volt lines for use on all timing circuits.

5.7.1. External DC Operation

Some models may be fitted with an External DC facility to enable operation of the pulse generator from an external DC supply or battery and may be recognised by a pair of terminals and an AC/DC changeover switch fitted on the rear panel. The external

DC (24V ±2V) supply may be connected to the terminals and the switch placed in the DC position. The "Power On" lamp is operated from the 17V DC rail and indicates in both AC and DC operation.

## SECTION 6

## CALIBRATION AND MAINTENANCE

### 6.1. Calibration

#### Power Supplies

No presets are fitted or necessary. Check supplies with a Model 8 Avometer or equivalent as follows:-

C63 positive.....+17 volts ± 1·5 volts.
Pin 14.....+5·4 volts ±0·75 volts.

### 6.2. Timing Circuits

The vernier controls of the PG-71 are fitted with readout dials indicating 1-10 (usable) these are intended to be used principally as logging dials but an approximate calibration is provided by setting the internal adjustment trimmers as in 6.1. et seq.

The dial reading is a direct multiplier function of the appropriate range switch setting (assuming all switch settings are compatible) and when calibrated in accordance with this section will allow direct setting of each function within ±1 dial division.

Before making any internal adjustments the positioning of the control knobs should be checked for correct alignment, i.e. each knob should be capable of adjustment from less than 1 to greater than 10.

If any knob is out of position, remove the cap insert, release the collet fixing screws and remove the knob from the shaft. Set the potentiometer fully anticlockwise and replace the knob in a position equivalent to a dial reading of 0·5 approximately.

Tighten the collet screw and check vernier can be adjusted to read approximately 10·5 in the fully clockwise position.

| Circuit. | Period. | Delay A. | Delay B. | Width A. | Width B. |
|---|---|---|---|---|---|
| Set Min (1) | RV3 | RV4 | RV10 | RV7 | RV13 |
| Set Max (10) | RV1 | RV6 | RV12 | RV9 | RV15 |

Table 6.1.

6.2.1. Connect PG-71 to a dual beam oscilloscope triggered from the sync output socket and terminate all lines in 50 ohms. If a dual beam oscilloscope is not available A and B should be adjusted separately.

6.2.2. Set oscilloscope amplifier to 5V/cm and time base to 2μS/cm. Set PG-71 range switches to the third position clockwise - period 10μ, delays and widths 1μ - and all verniers to 5.

6.2.3. Each trace will display a 10 volt positive going pulse approximately 5μS duration and occuring approximately 5μS after trace start. Increase delay verniers to 10 and adjust, RV6 and RV12 until the displayed pulses (A and B respectively) occur 10μS after trace start.

6.2.4. Reduce Delay Verniers to 1 and adjust RV4 and RV10 (A and B respectively) until pulses occur 1μS after trace start.

Repeat 6.2.3. and 6.2.4. until both conditions are met.

Set Delay verniers to 1 on completion.

6.2.5. Set Width Verniers to 10 and adjust RV9 and RV15 (A and B respectively) for displayed pulse widths of 10μS approx.

6.2.6. Reduce Width Verniers to 1 and adjust RV7 and RV13 (A and B respectively) for displayed pulse widths of 1μS approx.

Repeat 6.2.5. and 6.2.7. until both conditions are met. Set Width verniers at 3.

6.2.7. Set oscilloscope horizontal time base to display 10μS/cm. Set Period Vernier to 10 and adjust RV1 until only 2 pulses are visible on each trace and period is approximately 100μS.

6.2.8. Reduce Period Vernier to 1 and adjust RV3 until period between pulses is approximately 10μS (expand oscilloscope time base to 1μS/cm if required).

6.2.9. Repeat 6.2.7. and 6.2.8. until the Period Vernier tracks correctly.

6.2.10. Check PG-71 calibration on all other ranges using suitable oscilloscope settings and taking care that Pulse Generator settings are compatible before making any internal adjustment.

NOTE: As only one set of trimmers are fitted in each timing circuit it may be necessary to compromise on the setting of a particular range in order to set all other ranges within specification of ±1 dial position.

6.3. Set Output Source Impedance

6.3.1. Output A

(a). 10 volts into 50 ohms

Remove shorting links from terminals P30-P31 (L1b) and replace with link across terminals P29-P30 (L2b).

(b). 10 volts from 50 ohms

Remove shorting links from terminals P29-P30 (L2b) and replace with link across terminals P30-P31 (L1b)

6.3.2. Output B

(a). 10 volts into 50 ohms

Remove shorting links from terminals P25-P26 (L1a) and replace with link across terminals P24-P25 (L2a)

(b). 10 volts from 50 ohms

Remove shorting links from terminals P24-P25 (L2a) and replace with link across terminals P25-P26 (L1a).

N.B. On some units the source impedance links have been designated as follows:-

Output A

P29 was af
P30 was ae
P31 was ad

Output B

P24 was Z
P25 was aa
P26 was ab.

## SECTION 7

## APPLICATIONS

7.1. The PG-71 is an extremely versatile instrument having external trigger and gate facilities and two channels with independent delay width and amplitude controls. These, and the mixing facilities provided, enable many pulse configurations to be obtained which have previously only been available with two or more instruments or expensive modular systems. In the following paragraphs some of the capabilities of a single PG-71 are described and for more complex functions two PG-71 can be provided in a 17" rack-mounting cabinet.

7.2. Double Pulse - Independent Widths

It is often required to obtain a train of double pulses, the widths of each pulse being independently variable. This can be carried out with the PG-71 by the use of the channel mixing facilities (sections 3.8. and 5.5.). Waveforms obtained are shown in figure 7.1. It will be seen that when this facility is used, the delay and width of the added pulse are determined independently but both pulses at a given output have the same amplitude.

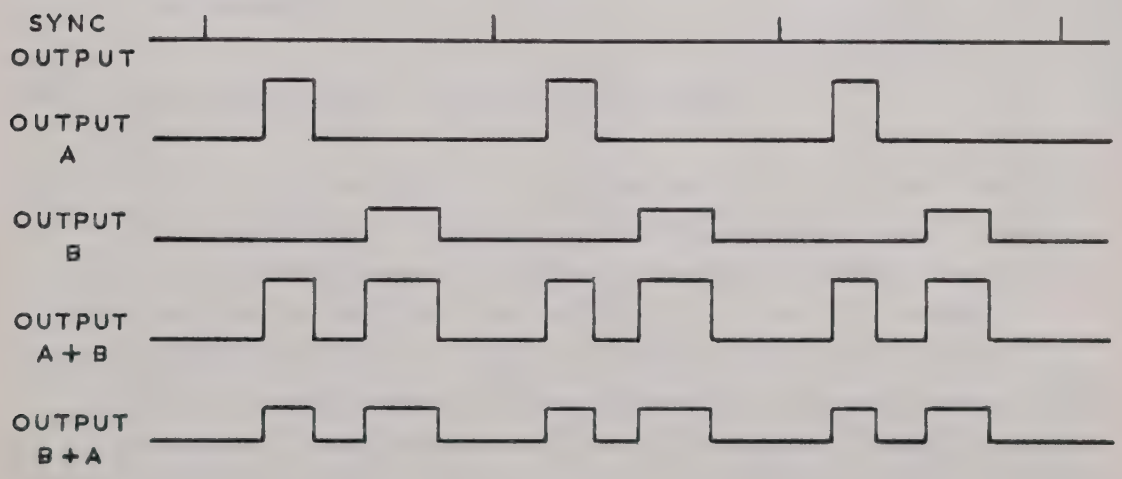



FIG 7.1.

## 7.3. Double Frequency Facility

7.3.1. For checking IC counters and dividers it can be useful to produce two simultaneous pulse trains, one at double the p.r.f. of the other. This can be achieved if one channel is operated in the combined mode and the other in the single pulse mode, with both widths the same and the delays adjusted to produce equal pulse spacing.

i.e. Similar to Fig. 7.1. outputs A and B+A but delay B adjusted for equal spacing.

7.3.2. To achieve this, proceed as follows:-

To obtain Channel A output at f
simultaneously with Channel B output at 2f

(a). Set period to 1/f
(b). Set widths A and B to the same setting (must be less than $\frac{1}{4}$ of the period)
(c). Set delay A to 50ns and delay B to half the set period (+50 ns).
(d). Set channel A mixer switch to 'A' and Channel B to B+A.

The amplitudes of the two pulse trains are adjustable independently.

## 7.4. True Double Pulse - Independent Amplitude

By the use of an external mixer the outputs of the two channels may be combined to produce a true double pulse mode comprising pairs of pulses each of which is independently adjustable in amplitude as well as delay and width. Figure 7.2. shows a suitable mixing circuit (output impedance links should be set for 10 volts from 50 ohms when using this circuitry (see section 6). Figure 7.3. demonstrates the difference between internal mixing, using the channel mixing switches, and external mixing which adds independent amplitude facility.

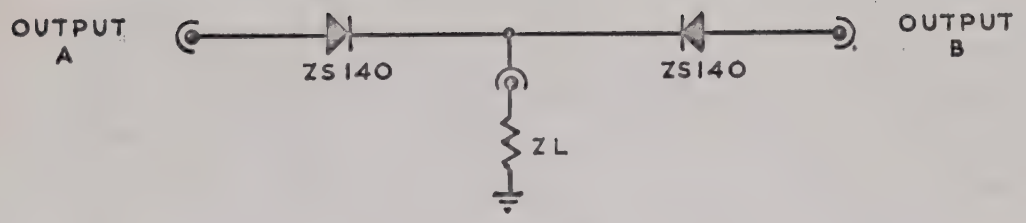



FIG. 7.2. - EXTERNAL MIXING

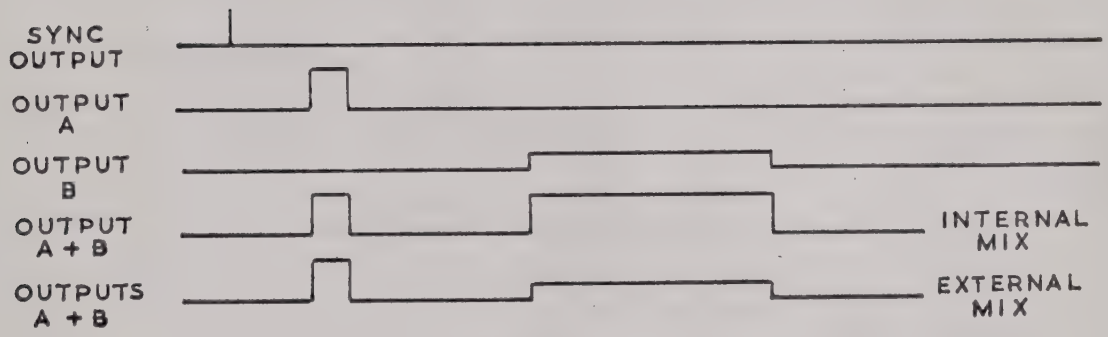



FIG. 7.3.

## 7.5. Narrow Pulse on Pedestal

This is a special variant of para.7.4. and demonstrates the flexibility provided by the availability of two independent pulse timing channels. Figure 7.4. demonstrates the ability to combine a narrow high amplitude pulse occuring during the generation of a wide pulse of lower amplitude by suitable adjustment of the front panel controls.

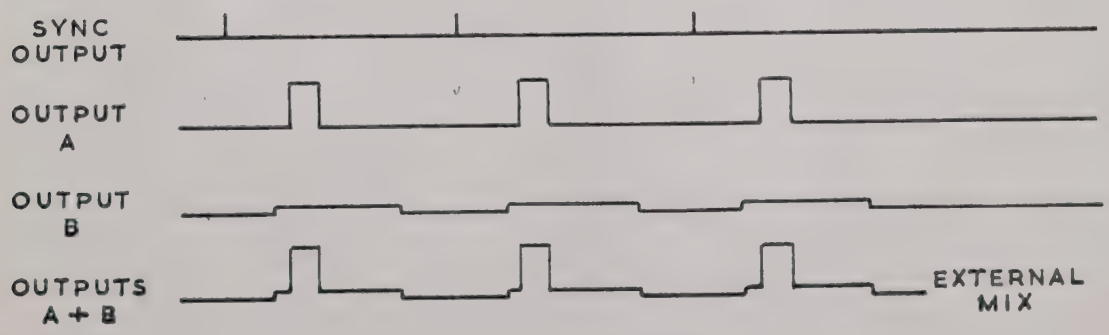



FIG. 7.4.

## 7.6. Pulse Advance Capability

For certain applications a pulse advance capability is desirable. This is obtained very simply in the PG-71 by using one of the two main outputs as an effective sync output the other as the main pulse output. If the main pulse output is set at minimum delay then the delay setting of the other channel provides the necessary pulse advance.

## 7.7. Generator Loads.

The PG-71 is designed to feed 50 ohm resistive load from:-

(1). A 50 ohm source when the output is limited to 100 mA.

(2). A high impedance source which the output will deliver 200 mA into 50 ohms.

For optimum pulse shape all output connections should be via 50 ohm coaxial cable terminated by a good quality 50 ohm load. When driving active loads such as transistors suitable stand-off resistors should be employed and UNDER NO CIRCUMSTANCES MUST THE CURRENT FED BACK TO OUTPUT SOCKET EXCEED 40 mA.

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